DOCUMENT – 906120

Wavelonics Operation and Maintenance Manual

INITIAL APPROVAL		
Function/Title	**Signature**	**Date**

REVISION HISTORY					
Rev	**Description**	**Date**	**Change Originator**	**Incorp by/ Date**	**Chkr/ Date**
A	Initial Release	4/26/2019	D. Hingston		

TABLE OF CONTENTS

1. Introduction

This manual contains instructions for the installation, operation, and maintenance of the WaveIonics treatment train. The intended audience of this document includes trained operators, technicians, and Water Tectonics personnel.

The WaveIonics system is designed to treat industrial stormwater using electrocoagulation and filtration as the primary treatment processes. Additional functions—such as pH adjustment, polymer injection, conductivity adjustment, and solids separation—improve the ability of the electrocoagulation and filtration stages to remove precipitates. The system monitors and manages effluent water turbidity and pH in real time. The effluent water quality parameter tolerances are user-configurable.

The WaveIonics system has been rigorously tested in both lab and field settings. With proper operation and maintenance, the system can remove the majority of total suspended solids (TSS), reduce dissolved metals, and break oil emulsion.

When the system is not being called upon to treat water (based on tank levels) and the freeze protection mode is active, the water is continuously recirculated to prevent freezing. The media filter pump is run at low speed, the discharge valve closes, and the freeze protect valve opens. In this configuration water is pumped from the settling tanks through the media filter and GAC back to the settling tanks. The EC pump piping is protected by a heat trace.

While in freeze protect mode, if the tank levels reach the pump on level setpoints, the pumps will be called and processing of water will be performed. After water levels drop to the pump off level setpoints, the recirculation mode will resume.

1.1. WaveIonics Electrocoagulation Treatment Train

- **Electrocoagulation (EC):** Electrocoagulation is the core of the WaveIonics treatment train. Influent water passes around charged plates in the EC cells. The charged plates electrically destabilize suspended solids, promoting coagulation.

  The EC stage is activated when a water level transducer located in the customer's source tank signals the WaveIonics control system that the source tank level is greater than the **ON** setpoint programmed into the control software. The control system puts the EC stage in standby when the level transducer signal falls below the **OFF** setpoint.

- **Conductivity Adjustment:** The system adjusts the conductivity of the water before the EC stage. This enables the system to operate more efficiently and use less power.

- **Polymer Injection:** The system has the capability of injecting a polymer additive to increase coagulation of the solids so that a larger amount of pollutants is removed from the water.

- **Separation/Settling and Coagulation:** The system includes three interconnected settling tanks. Coagulation and flocculation of particles charged in the EC cells is facilitated by the tanks' weir structure and internal mixers.

  Influent water characteristics determine the rate at which sediments precipitate out of solution and aggregate to form coagulated precipitates in the settling tanks.

- **pH Adjustment:** The system monitors the pH at three stages: before EC, after EC in the settling tank, and after media filtration. Chemical injection is used to raise the pH of the water after EC before it enters the settling tanks. Carbon dioxide (CO_2), a weak acid, is injected after the media filter stage to lower the pH to within the target discharge range.

- **Filtration:** Media filtration removes the remaining solids that are too small to precipitate out in the settling tanks. Granular activated carbon (GAC) filters are then used to absorb any remaining contaminants. The WaveIonics treatment train incorporates the customer's existing media filtration system and GAC filter.
- **Water Quality Monitoring**: If the water quality parameters of turbidity and/or pH are exceeded, the system has the ability to recirculate this effluent water until water quality is within configured parameters.

1.2. Safety Information

Read this entire manual before operating this equipment. Pay attention to all warning, danger, and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

To ensure that the safety and protection mechanisms designed into this equipment are not impaired, do not use or install this equipment in any manner other than that specified in this manual.

1.2.1. Operational Safeguards

The WaveIonics system is equipped with an external power disconnect panel to provide a single point for power management.

Terminal caps are installed on the tops of each treatment cell terminal in the WaveIonics system to prevent accidental contact. Exercise caution at all times while working inside the system. Do not disconnect or reconnect any cell leads while the EC system is operating. Do not operate the system without the cell leads connected and the cells filled with water.

1.2.2. Safety Notations and Symbols

The following notations emphasize important safety information in this manual:

- **DANGER:** Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.
- **WARNING:** Indicates a potentially hazardous situation that may result in minor or moderate injury.
- **Note:** Information that requires special emphasis or attention.

1.3. Terminology

The following table details the terminology used in this document.

Term	Definition
AAC	Amperage Alternating Current (AC)
ADC	Amperage Direct Current (DC)
CO_2	Carbon dioxide, a weak acid used for pH adjustment.
EC	Electrocoagulation
Flocculation	Clumping together of coagulated particulates
GAC	Granular Activated Carbon
gpm	gallons per minute
HMI	Human Machine Interface, the system touch screen
hp	Horsepower, a measurement of power.
µS	microsiemens, a measure of conductivity.
MF	Media Filter
PLC	Programmable Logic Controller
psi	Pounds per square inch
PSV	Pressure Sustaining Valve
NTU	Nephelometric Turbidity Units, a measure of water clarity.
TSS	Total Suspended Solids
VAC	Volts Alternating Current (AC)
VDC	Volts Direct Current (DC)
Volts	Used in context, usually means VDC.

Table 1: Terminology

2. System Power Requirements

The system requires a 480 VAC, 3-phase, 300 amp electrical service at the treatment site.

3. WaveIonics Internal System Components

This section describes components inside the WaveIonics Conex (container unit).

3.1. Chemical Injection Pumps

At different points along the treatment train, diaphragm pumps inject chemicals for the following purposes:

- The brine injection pump injects a salt brine solution before EC to raise the conductivity of the water.
- The caustic injection pump injects caustic after EC to raise the pH.
- If used, the polymer injection pump injects a polymer additive after EC and before the settling tanks to aid flocculation.

The pumps are controlled by their respective **OFF/AUTO** switches on the control cabinet door. Set the switches to the **AUTO** position to enable the desired pumps. Automatic operation for the caustic pump is controlled by feedback from a programmable pH setpoint in the sc1000.

The caustic, brine, and polymer injection pumps are interlocked with the EC pump to ensure no chemical injection occurs without circulating water.

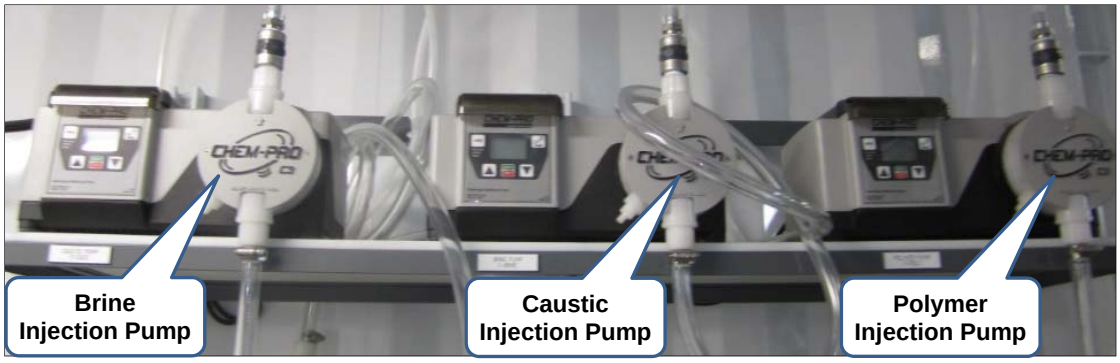


Figure 1: Chemical Injection Pumps

3.2. Human Machine Interface (HMI)

Located inside the Conex, on the outside of the control cabinet door, the Siemens HMI is the main system control interface.

WARNING: Use caution when programming the **ON/OFF** setpoints on the WaveIonics HMI. Always ensure that all pumps are operating with an adequate water supply. Incorrectly programming the setpoints may cause the pumps to run dry, which can result in damage to the pumps.

Figure 2: Human Machine Interface

3.3. Switches and Indicators

System Switches and Indicators are located below the HMI on the outside of the control cabinet door.

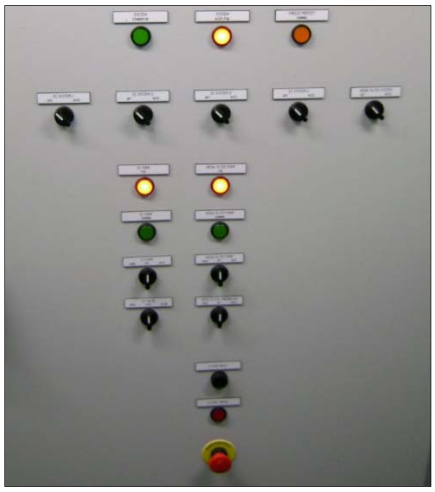


Figure 3: Switches and Indicators

3.4. Programmable Logic Controller (PLC)

The primary system controller is the Siemens PLC, located inside the Conex control cabinet. The PLC monitors electrical feedback circuits and provides system control signals.

Electrical inputs include control panel switches, level transducers, valve position, flowmeter readings, pump status, EC stage power supply amperage and voltage, cell over-temperature status, and other inputs. Control signals include pump call, EC stage power supply amperage, and other control signals.

Figure 4: Siemens PLC

3.5. Variable Frequency Drives

The WaveIonics system features five VFDs, located inside the control cabinet, that drive the EC and MF supply pumps as well as the three mixer motors.

The pump VFDs provide a soft-start function that moderates current and torque peaks during startup. VFD functions reduce water hammer, overall pressure in the system, and overall power consumption.

Figure 5: VFDs

The EC supply pump VFD regulates the flow rate and dynamically adjusts the rate based on the number of EC subsystems in operation. This VFD uses a closed-loop proportional-integral-derivative (PID) algorithm to regulate flow rate. The flow rate per subsystem information is shown in Table 2 below.

EC Subsystems in Operation	Flow Rate
1	150 gpm
2	300 gpm
3	450 gpm
4	600 gpm
Max Hydraulic Flow	800 gpm

Table 2: Flow Rate per Subsystem

3.6. Hach sc1000 Controller

The Hach sc1000 is a multiparameter controller that includes a display module and probe connections. The controller monitors the water pH level, conductivity, and turbidity in real time and provides decisive switching between effluent recirculation and discharge.

Water quality data is digitally stored on the sc1000. An operator can download the sc1000 data records to a computer or memory card. The operator can customize the sc1000 display using the touch screen controls to show multiple combinations of desired parameters.

Figure 6: Hach sc1000 Controller

3.7. Conductivity Probe

This probe measures the influent water conductivity. The sc1000 monitors the probe output and displays the current conductivity of the water. The sc1000 uses the conductivity probe reading to control the brine dosing rate pre-EC. Water conductivity can also serve as useful information for system troubleshooting.

WARNING: Do not store the conductivity probe at temperatures below **15 °F (-9.4 °C)**.

Note: Refer to the *GLI 3700sc Digital Inductive Conductivity Sensor User Manual* for maintenance, cleaning, and calibration schedules and procedures.

Figure 7: Conductivity Probe

3.8. Electrically-Actuated Valves

The electrically-actuated valves control water flow based on signals from the Siemens PLC. The valves feature a visible position indicator as well as manual override capabilities. The hand wheel mounted on the side of the valve can be used to manually control the valve position.

WARNING: Use extreme caution when manually controlling the valve position to prevent deadheading the pumps, over-pressurizing a pipe, or creating a condition that could potentially damage equipment.

Figure 8: Electrically-Actuated Valve

3.9. Cell Isolation Valves

Each EC cell features three isolation valves. The upper and lower valves are manual ball valves. These valves must be open during normal operation. The manual valves are used to isolate an EC cell for service.

Located directly below the upper manual valve is a motorized software-controlled valve. The motorized valves are grouped together by EC cell subsystem. The motorized valves open when the EC stage is running and close when EC is off or in standby to prevent the discharge of untreated water.

Note: A switch on the back of the motorized valve controls the cam synchronization. The operator can use the switch to manually open a motorized valve or disable actuator power. Refer to the Jandy Installation and Operating Manual Jandy Valve Actuator document for more information.

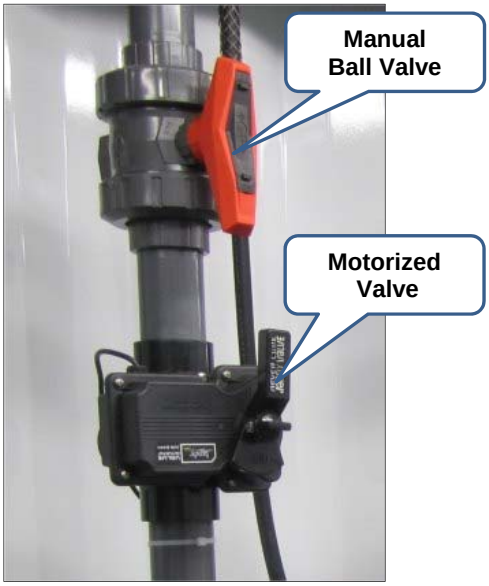


Figure 9: EC Cell Isolation Valves

3.10. EC Cells

An EC supply pump moves water from the source tank and through the EC cells.

Over time, the metal plates in the EC cells are consumed by the electrocoagulation process. This reduces the efficiency and effectiveness of the cells to the point where replacement is recommended. To order replacement EC cells, contact Water Tectonics. For information on inspecting, cleaning, and replacing EC cells, refer to the *Inspecting, Cleaning, and Replacing Cells* section.

Figure 10: EC Cells

3.11. EC Power Supplies

The EC power supplies, located in the control cabinet, provide power to the EC cells.

DANGER: Do not attempt to service, configure, or repair any power-related equipment in the WaveIonics system. **Only qualified Water Tectonics personnel should service any equipment in the electrical control cabinet.**

Figure 11: EC Power Supply

3.12. Flowmeters

The flowmeters monitor both the EC influent and media filter effluent flow rate and communicate the information to the HMI. They also provide digital displays showing real-time flow rate information. The operator can use flowmeter readings to gauge system performance, alert them to a system problem, and record discharge totals for regulatory purposes.

For additional information about the flowmeters, settings, display options, and calibration procedures, refer to the manufacturer's documentation.

Figure 12: Flowmeter

3.13. pH Probes

There are three pH probes used for water quality monitoring in the following locations:

Before EC: The sc1000 displays this pH reading for reference purposes. Note that chemical dosing is not based on the reading.

First chamber of the settling tank: The sc1000 sends control signals that adjust the caustic injection rate based on this pH reading.

After the media filter: The sc1000 sends control signals that control the CO_2 injection rate based on this pH probe reading.

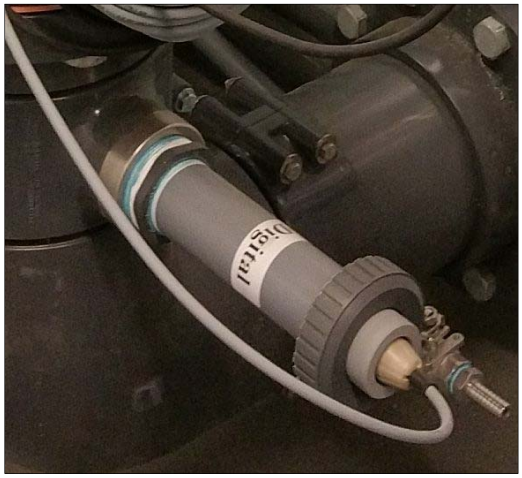


Figure 13: pH Probe

The pH probe output is monitored by the sc1000. The sc1000 sends control signals that open or close valves to direct water to discharge or recirculate through the treatment train based on the second pH probe reading.

WARNING: To avoid damage, do NOT store the pH probes at temperatures below **40 °F (4.4 °C)**.

WARNING: If the pH probe is stored for more than 48 hours in an offline system drained of water, keep the pH probe salt bridge wet by removing the probe and attaching the protective cap. **Allowing the pH probe salt bridge to dry out will permanently damage the probe.**

3.14. Turbidity Monitoring Probe

A turbidity probe is used to measure the clarity of the water exiting the media filter. The probe output is monitored by the sc1000. The sc1000 sends control signals that open or close valves to direct water either to discharge or to recirculate through the treatment train based on the turbidity probe reading.

Figure 14: Turbidity Probe

3.15. Chemical Storage and Delivery

The caustic, brine, and polymer are stored in chemical-resistant totes (large tanks used to store and transport fluids and other bulk materials).

The caustic tote, brine tote, caustic drum, polymer drum, are stored inside the WaveIonics Conex.

The caustic and brine are delivered by chemical pumps to the pre-treatment tank.

Figure 15: Example Brine Tote

The brine tote is filled with salt and water. A float inside the brine tote controls a valve that provides additional water from the influent water flow when the brine level falls too low.

The CO_2 is stored in dewar tanks outside the Conex and delivered to the treatment train by a regulated pressure line placed after the media filter.

WARNING: Do NOT use water softener pellets or other chemicals instead of salt.

3.16. Emergency Stop

The Emergency Stop Button is located on the outside of the control cabinet door.

When activated, the fail-safe emergency stop push button (E-Stop) disconnects power to all rotating devices, all motor loads, the EC treatment equipment, and also closes the motorized cell isolation valves. Other items such as lighting and the HMI remain powered. The internal E-Stop button is located on the control cabinet door.

To reset the E-Stop, first rotate the button clockwise. Then press the **E-STOP RESET** button.

Figure 16: Emergency Stop Button

3.17. Unmanaged Ethernet Switch

The Unmanaged Ethernet Switch enables communication between the HMI, PLC, sc1000, and the wireless modem.

Figure 17: Ethernet Switch

3.18. TosiBox Connectivity Device

The Tosibox connectivity device provides secure remote access to the system over the internet.

Figure 18: TosiBox Connectivity Device

3.19. Red Lion Protocol Converter

The protocol converter allows other systems to communicate with the Siemens HMI and PLC for remote monitoring.

Figure 19: Red Lion Protocol Converter

3.20. Modem

The wireless modem allows connection to the WaveIonics system.

Figure 20: Modem

3.21. CO_2 Sensor

This sensor monitors ambient CO_2 inside the Conex. Audible and visual alarms indicate when CO_2 concentration has exceeded the recommended level.

Figure 21: CO_2 Sensor

3.22. Panelboard, Load Center and Transformer

The 480 VAC panelboard holds breakers for all equipment—such as pumps or the EC system—that requires 480 VAC power.

The 120 VAC load center holds breakers for all equipment—such as lights or outlets—that requires 120 VAC power.

The step-down transformer converts 480 VAC to 240 VAC power.

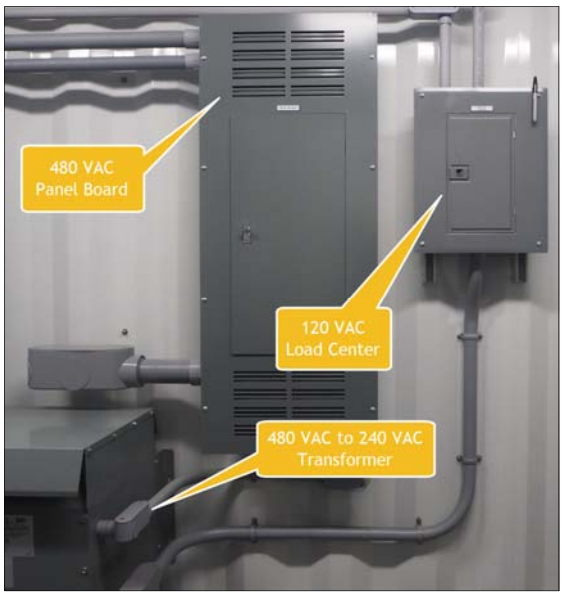


Figure 22: Panelboard, Load Center and Transformer

4. External Components

This section describes components that are located outside the WaveIonics Conex.

4.1. Water Collection and Source Tank

Water enters the WaveIonics system from the customer-owned source tank. Water collection and storage in the source tank are managed by the customer and are outside of the scope and control of the WaveIonics system.

Water that does not meet final discharge criteria is automatically recirculated to the source tank for further treatment. Recirculation and treatment continue until the water meets the final discharge criteria.

4.2. EC Supply Pump

A 480 VAC 3-phase flooded suction centrifugal pump moves water from the source tank through the EC stage. The pump is controlled by the EC Pump Switch on the control cabinet door. The operator can select from **HAND** (Manual), **OFF**, and **AUTO** operation.

For detailed pump information and maintenance instructions, refer to the manufacturer's documentation.

Figure 23: EC Supply Pump

4.3. Level Transducer

A level transducer located in the customer's source tank monitor the water level and signals the WaveIonics system to activate the EC supply pump when the water rises above a programmable setpoint. The EC stage will transition to standby when the water drops below a programmable setpoint.

A second level transducer located in settling tank 1 signals the system to activate the media filter supply pump when the water level in settling tank 1 rises above a programmable level. The media filter supply pump will transition to standby when the water drops below a programmable level.

Figure 24: Example Level Transducer

NOTE: When installing a level transducer, ensure the transducer sinks to the bottom of the tank and is located far enough from any outlets that it is not pulled in by pump suction or outlet flow.

4.4. Settling Tanks

The WaveIonics system includes three settling tanks, which are connected at both ends by manifolds. Each tank is configured internally as a trio of interconnecting compartments. Two partial walls allow water to flow over one and underneath the other, like a weir. The resulting perturbation of the water flow encourages particles to coagulate.

Water exits the third compartment, or clear well, and enters an output manifold. From the output manifold, the media filter supply pump pumps the water through the customer-owned media filtration system.

NOTE: Drain and clean the settling tanks annually, during the non-rainy season. Dispose of the sludge in the nearest licensed waste disposal facility.

4.5. Slow Mixing

Mixers in the first compartment of each settling tank churn the water slowly to promote flocculation of coagulated solids, which combine until they either float to the top or fall to the bottom.

Each mixer is calibrated to provide mixing efficiencies in particle size flocculation to allow optimal settling in the second compartment before the water enters the clear well (or third) compartment and is then sent on to the media filtration tanks.

The mixing motors are powered by adjustable VFDs. A local disconnect is provided within line of sight of the mixing motors.

4.6. Media Filter Supply Pump

A 480 VAC 3-phase flooded suction centrifugal pump pushes water from the settling tanks through the media filter. The media filter pump control switch is located on the control cabinet door. The operator can select **HAND** (Manual), **OFF**, or **AUTO**.

For detailed pump information and maintenance instructions, refer to the manufacturer's documentation.

Figure 25: Example Media Filter Supply Pump

4.7. Media Filter

The customer-owned media filtration system removes additional suspended solids from the water. This WaveIonics system includes a pressure sustaining valve to assist periodic backflushing.

For media filter operating instructions, refer to the customer operation and maintenance manual, revision 17, Sept. 2016. New section pages 29 through 68 provide instructions for the Everfilt Media Filter. New section pages 1 through 28 provide instructions for the self-flushing Amiad auto filter that is also part of the media filter system.

4.8. Pressure Sustaining Valve

A pressure sustaining valve is installed immediately downstream of the media filter to ensure there is sufficient pressure for the backflush process to break up contaminates in/on the media bed and to provide consistent flushing action.

The set screw for the PSV should be set to maintain approximately 35 psi.

Figure 26: Example Pressure Sustaining Valve

4.9. Air Compressor

The customer-provided air compressor actuates the backflush valves on the media filter.

The filtration system typically requires between 35 to 45 psi of pressure to the media filter to push water through the media. Backflushing operations typically require a pressure 5 to 10 psi higher than the media filter pressure for proper operation. Under normal operation an air compressor setting of approximately 50 psi is sufficient to perform a backflush.

Note that these figures are estimates - refer to the media filter manufacturer's documentation for information on how to properly set the air pressure required for a backflush.

Refer to the air compressor manufacturer's documentation for information such as maintenance schedules.

4.10. Heated CO_2 Regulator and Solenoid

When the pH probe located downstream of the media filter signals that water pH is too high, the solenoid opens and CO_2 is released into the water. The CO_2 regulator controls how much CO_2 is released, based on instructions it receives from the sc1000. Heating the regulator eliminates ice buildup.

Figure 27: Heated CO_2 Regulator and Solenoid

4.11. CO_2

The CO_2 is stored in dewar tanks outside next to the WaveIonics Conex.

4.12. Freeze Protection Thermostat

A thermostat on the outside of the WaveIonics Conex triggers the freeze protection mode when the temperature goes below the setpoint.

4.13. System Disconnect

The system power disconnect is a lever on the right side of the fused disconnect, located on the Conex exterior. To disconnect all power to the system, pull the lever downward to the locked position. **Follow all company lockout/tagout procedures prior to performing any electrical service or maintenance.**

Figure 28: System Disconnect

4.14. Low Voltage and High Voltage Junction Boxes

Equipment that is physically located outside the Conex is connected to either breakers or the control cabinet through one of these junction boxes.

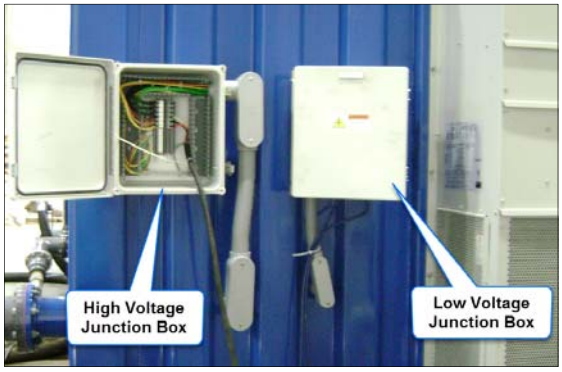


Figure 29: Junction Boxes

5. Operation

5.1. HMI Interface Screens

Use the HMI to control and monitor the WaveIonics system and to set system parameters.

5.1.1. System Page

The System Page provides a real-time snapshot of overall system function and performance. The Systems Page can be accessed by pressing the System Home Button at lower left. Use the System Page to see the following:

- High Flow Bypass status
- Reservoir (Source Tank) and clear well water levels
- Pump status (go to the Pumps Page for runtimes)
- Water quality parameters (pH and turbidity)
- Flow rates as measured by the flow meters (go to the Pumps Page for flow totals)
- Electrically-actuated valve positions (open or closed)
- EC cell power supply status
- EC system status
- Discharging or recirculating water status with freeze protection recirculation flow
- System alarms

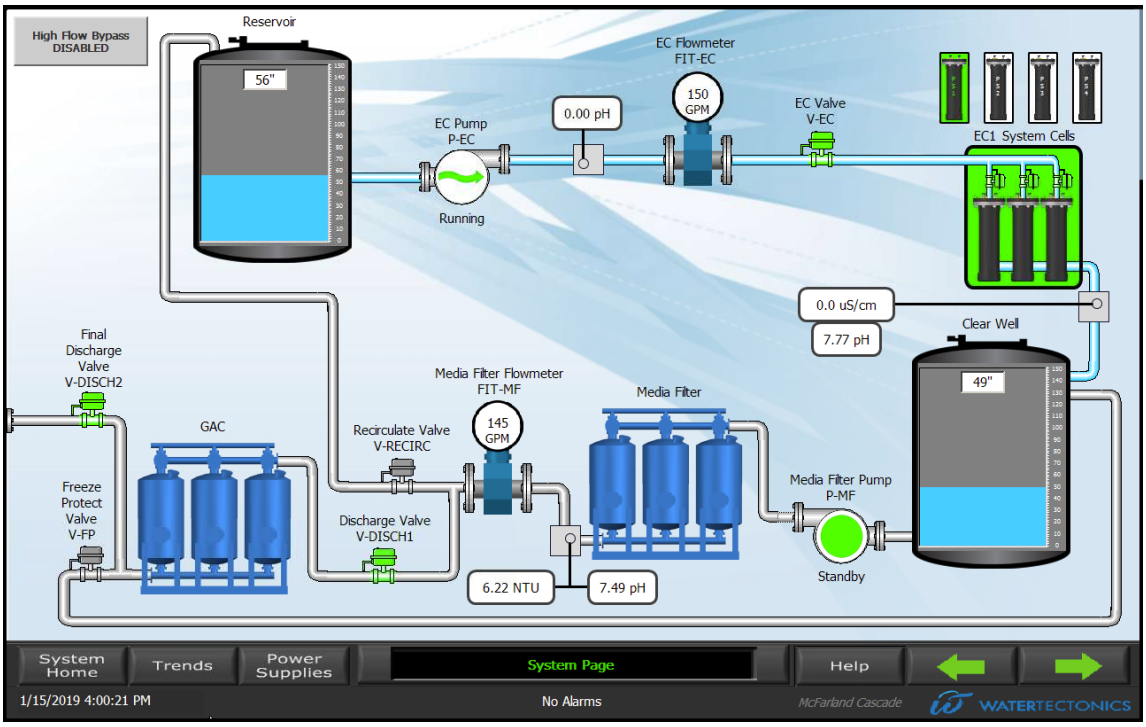


Figure 30: System Page

Icon appearance changes to reflect component status during operation.

HIGH FLOW BYPASS BUTTON:

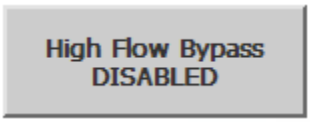
Icon	Meaning
	Press this button to enable or disable the high flow bypass mode.
	When the high flow bypass mode is enabled, customer-owned pumps pump water from the source tank directly to the media filter. When this feature is enabled, the software will estimate the gallons of water being bypassed. This estimate will be based on the effluent flow rate minus the EC flow rate and the gallons of settling tank.

Table 3: High Flow Bypass Button States

PUMP ICON STATES:

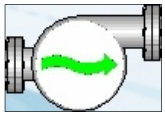
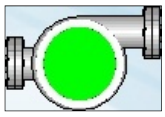
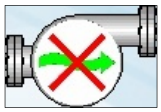
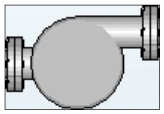
Icon	Meaning
	The supply pump is called.
	The supply pump is in standby mode.
	The supply pump has failed or the flow rate has dropped below 20 gpm for more than 30 seconds. This could indicate a problem with the pump or water supply.
	The supply pump is OFF.

Table 4: Pump Icon States

VALVE AND PIPE ICON STATES:

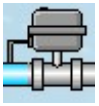
Component	Icon First State	Icon Second State
Electrically-Actuated Valve	 (Closed)	 (Open)
Hydraulic Pipe	 (No water flow)	 (Water flow)

Table 5: Valve and Hydraulic Pipe Icon States

EC SYSTEM ICON STATES:

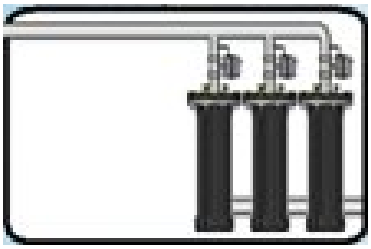
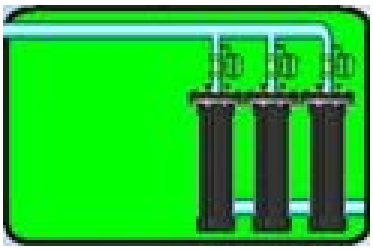
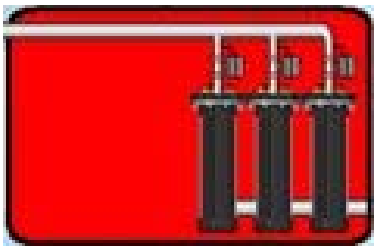
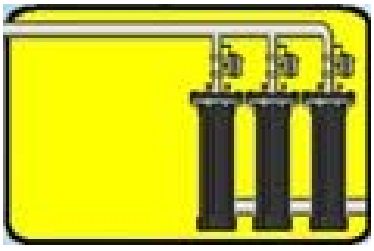
Icon	Meaning
	Electrocoagulation is off.
	Electrocoagulation is running normally.
	Electrocoagulation shut down due to an error condition.
	Electrocoagulation is in standby mode.

Table 6: EC System Icon States

EC CELL POWER SUPPLY:

Icon	Meaning
	Power supplies for all 4 EC subsystems are up and running.
	This is an example showing an error in EC Subsystem 2. To investigate, do the following: • Press the power supply icon to go to the EC Systems Page to see the specific EC cell that is affected, or, • Press the Alarm Button  at the bottom center of the HMI to investigate the error condition.

Table 7: EC Cell Power Supply Icon States

ALARM BUTTON:

Icon	Meaning
	Located below the page title, the Alarm Button displays alarm status for all system components.
	Press the Alarm Button when it displays the “Check Alarms” status to jump to the Alarms Page.

Table 8: Alarm Button States

5.1.2. Pumps Page

The Pumps Page displays the following information:

- EC and Media Filter supply pump status
- EC and Media Filter supply pump run times
- Flow rates
- Flowmeter totals
- Quick links to selected pages (Press the Gallons Button to change the unit of measurement.)

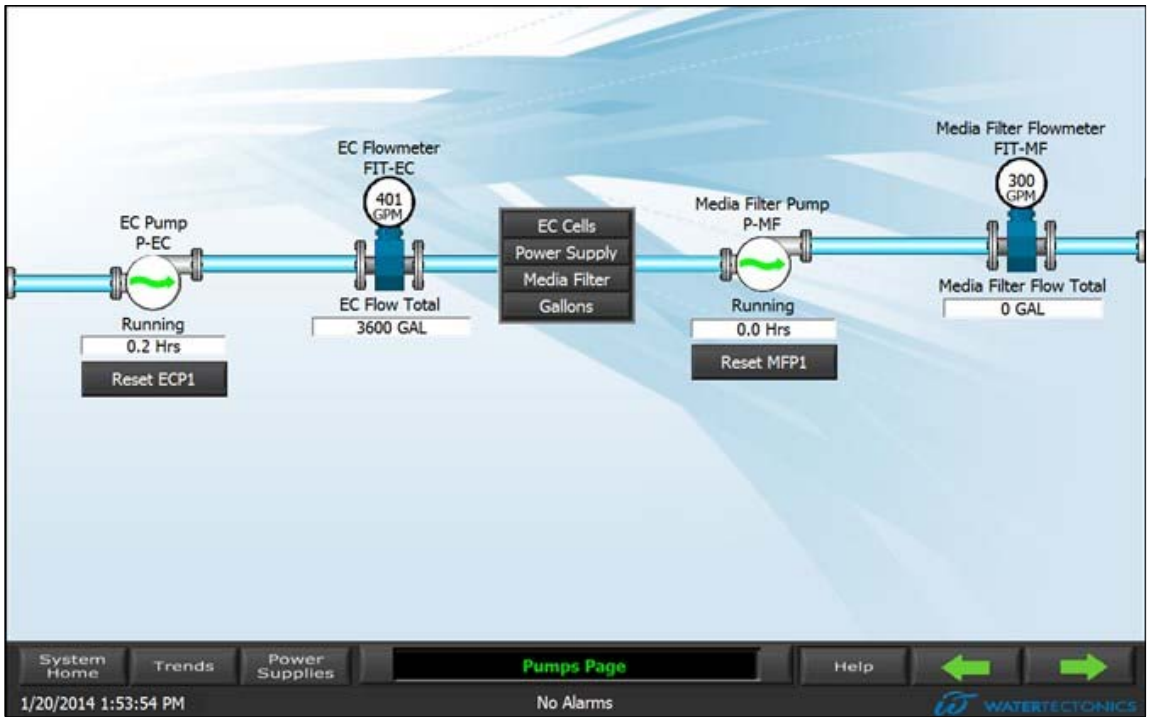


Figure 31: Pumps Page

5.1.3. Power Supplies Page

The Power Supplies Page displays the real-time status of the EC subsystem power supplies. Use the Power Supplies Page to do the following:

- Set target current
- Monitor cell resistance

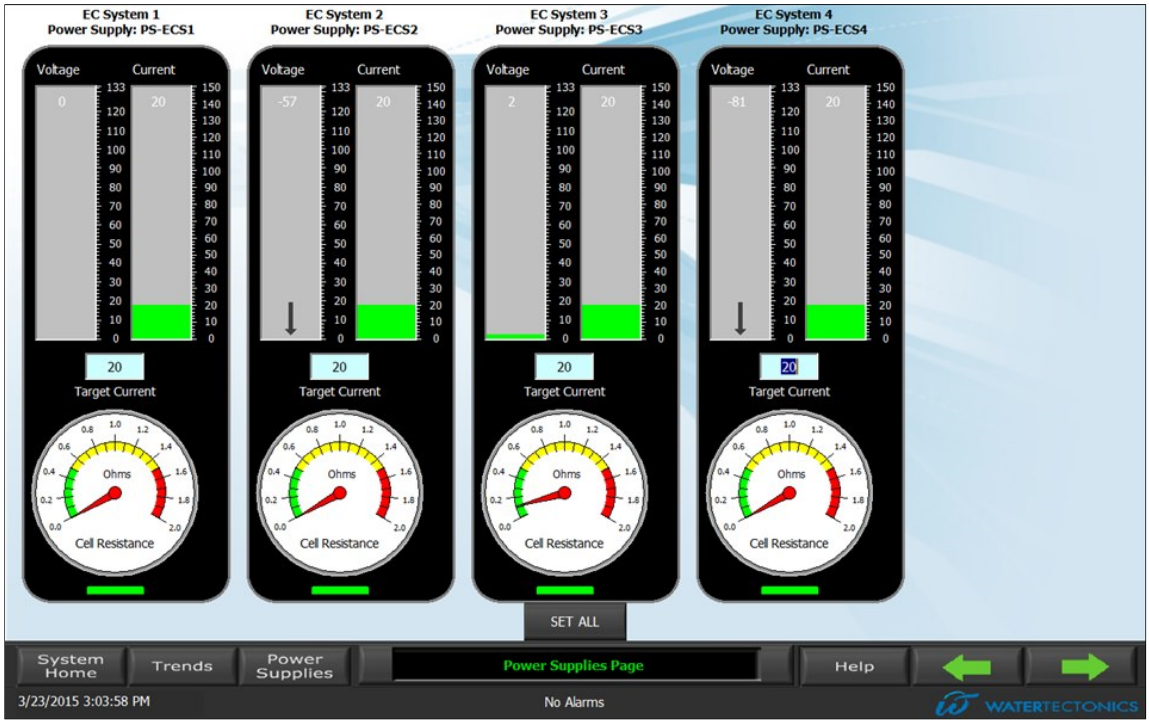
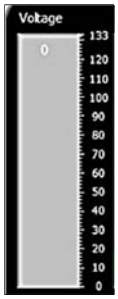
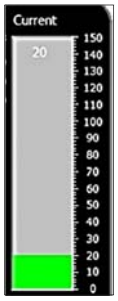


Figure 32: Power Supplies Page

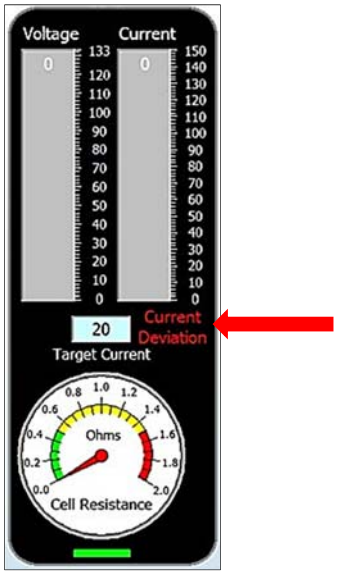
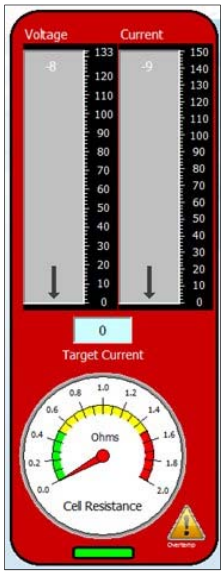
TARGET CURRENT:

Icon	Meaning
	Press the Set All Button to set the same target current for all EC power supplies.
	Press the numeric indicator to set the target current for an individual power supply.

CELL RESISTANCE:

Icon	Meaning
	The Voltage Indicator Bar displays the DC voltage supplied to the EC cell. The voltage value is measured at the power supply output in DC volts (VDC).
	The Current Indicator Bar displays the DC current passing through the EC cells. The current value is measured at the power supply output in DC amperes (ADC).
	The Cell Resistance Indicator displays the EC cell subsystem resistance in ohms. Cell resistance varies due to variations in cell configuration, cell conditions such as fouling or plate consumption, and water conductivity. Cell resistance measurements in conjunction with water conductivity readings are used for estimating cell wear and troubleshooting various issues. Cell resistance is calculated using Ohm's law: $$R = \frac{V}{I}$$ where ***R*** is the resistance of the conductor in units of ohms. ***V*** is the potential difference measured across the conductor in units of volts. ***I*** is the current through the conductor in units of amperes.

POWER SUPPLY ERROR STATUS ICONS:

Icon	Meaning
	**Current Deviation Error:** This error occurs when a subsystem cannot meet the target EC treatment current for more than 30 seconds. A current deviation error can be a sign of cell wear, cell fouling, consumed plates, low water conductivity, or other electrical issue.
	**Over-temperature Error:** This error occurs when the internal power supply temperature exceeds a set limit for more than 30 seconds. If an over-temperature error occurs, check the environmental conditions inside the WaveIonics unit and electrical cabinet. Ensure all fan filters are clear and all fans are operating properly. The power supply will automatically resume operation when the internal temperature returns to operational limits.

5.1.4. EC Systems Page

Use the EC Systems Page to identify cells with over-temperature errors, monitor cell run times, and check EC valve position. Press the Reset Cell Times Button to reset run-time.

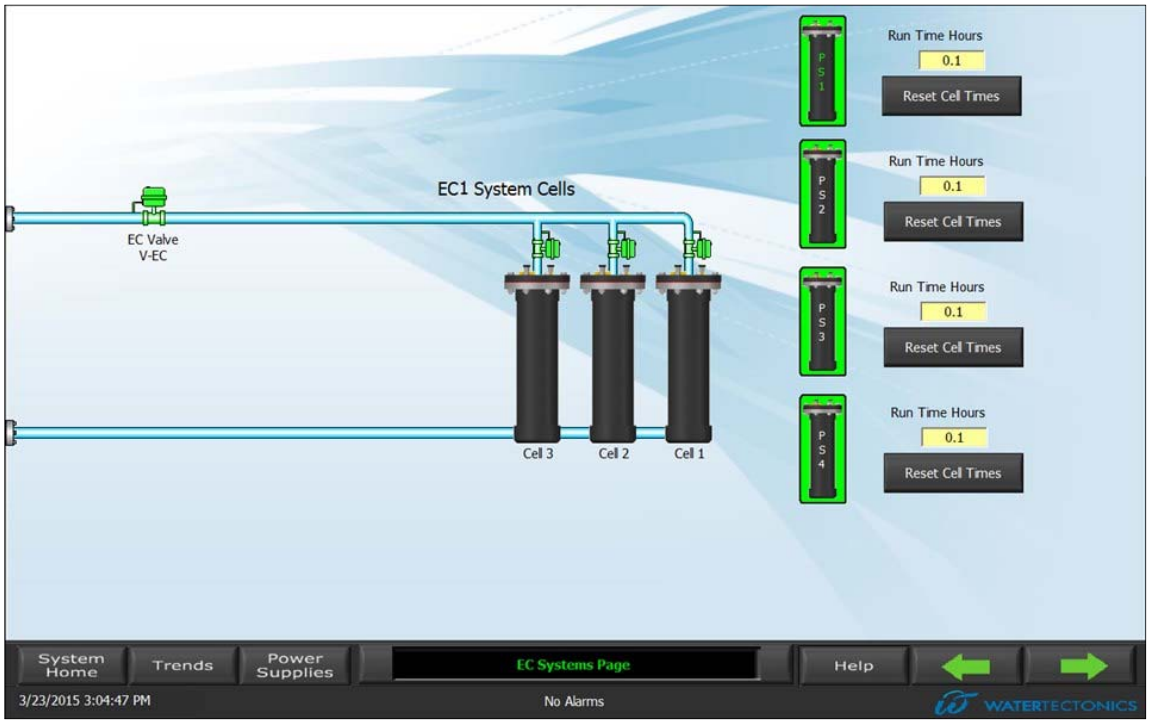


Figure 33: EC Systems Page

OVER-TEMPERATURE ERRORS:

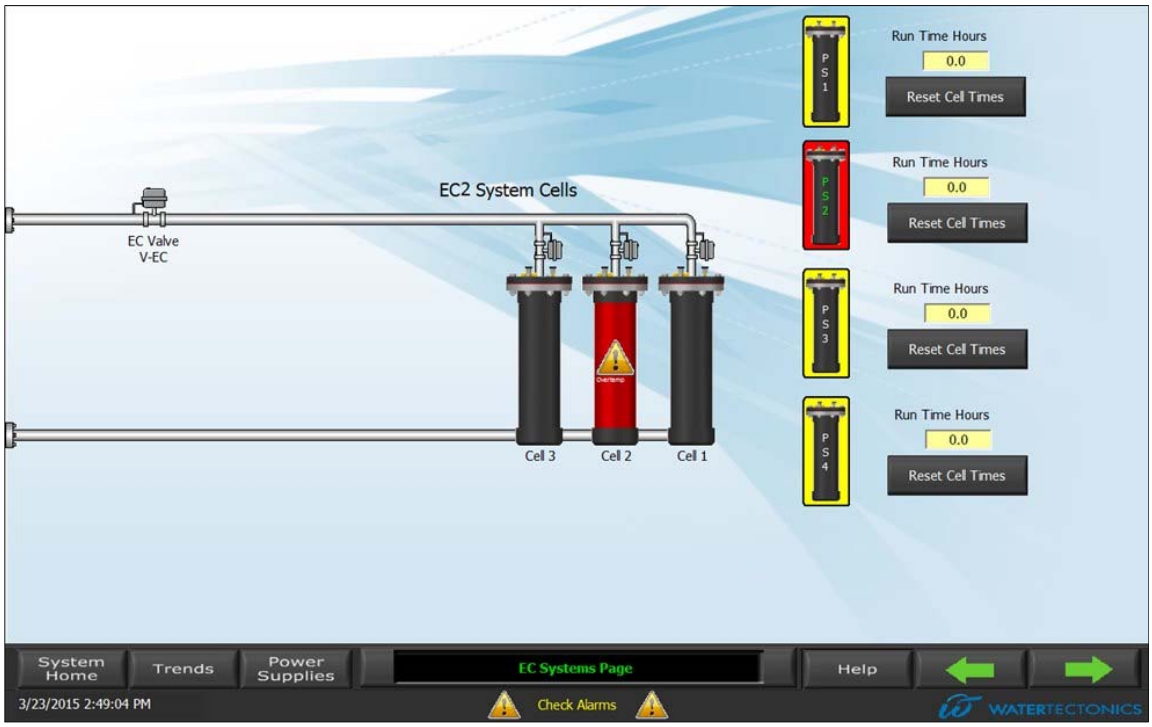


Figure 34: EC Systems Page with Over-temperature Error

If an over-temperature error occurs, the Power Supply icon for the associated subsystem will turn red. Press the Power Supply Icon to view information about the associated subsystem.

5.1.5. Reservoir Page

The Reservoir Page displays the following information:

- Reservoir (Source tank) level
- EC supply pump status
- EC subsystem on and off setpoints

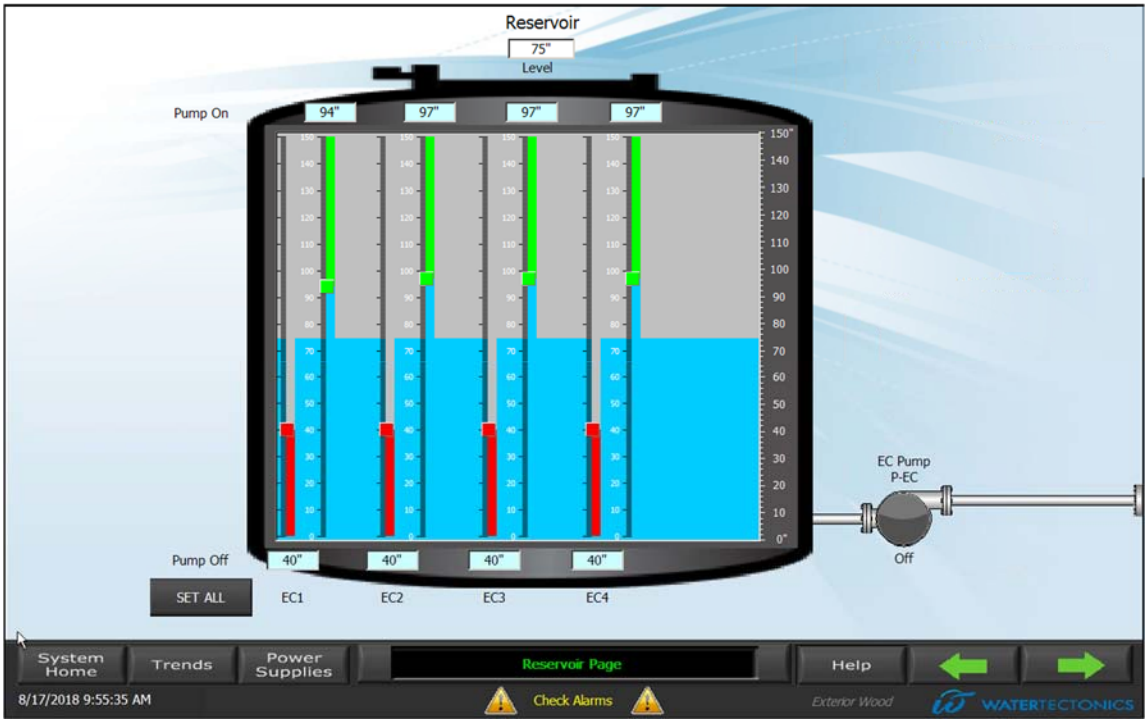


Figure 35: Reservoir Page

To define the level setpoints for the source tank, complete the following steps:

1. Drag the green square to set the level where the EC subsystem is turned on.
2. Drag the red square to set the level where the EC subsystem is deactivated.

The minimum and maximum allowed values will appear above the indicator.

The operator can define different on and off setpoints for each EC subsystem. This allows for different levels of system utilization and power consumption based on the reservoir water level.

An EC subsystem is enabled when the corresponding switch on the control cabinet door is set to AUTO.

- When the water level reaches the lowest of EC subsystem green squares (the **ON** setpoint) the EC pump will turn on.
- When the water level reaches the lowest of the EC subsystem red squares (the **OFF** setpoint) the EC pump will turn off.

5.1.6. Media Filter Page

The Media Filter Page allows the operator to monitor the clear well and media filter system by displaying the following information:

- Mixer motors (The mixer motor icons are **green** when running, **yellow** in standby, and **red** when failed.)
- Clear well level and media filter pump on and off setpoints
- Media filter pump status
- Media filter flowmeter reading
- Flow totals
- Electrically-actuated valve positions
- Backflush status
- Freeze protection status
- Recirculation and discharge status
- Recirculation and discharge totals

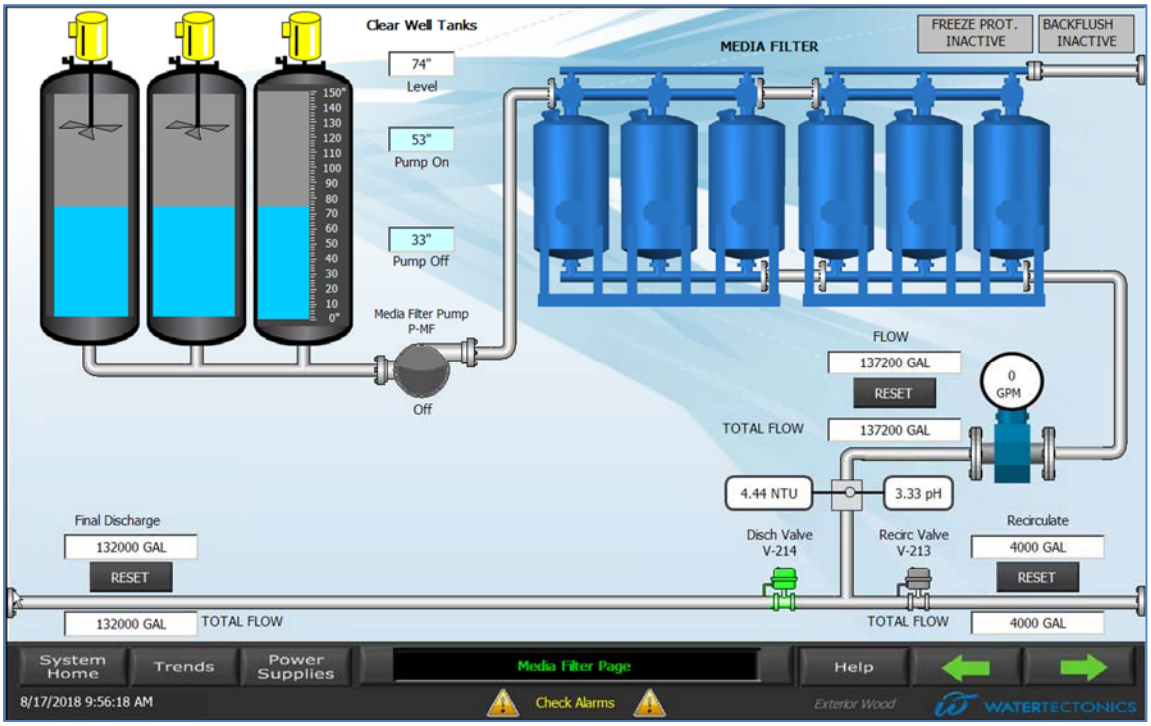


Figure 36: Media Filter Page

To define the level setpoints for the clear well, complete the following steps:

1. Press the **Pump On** level indicator to change the setpoint of the level where the pump is called.
2. Press the **Pump Off** level indicator to change the setpoint of the level where the pump is deactivated.

When the **Pump Off** and **Pump On** indicators are pressed to enter the setpoints, the minimum and maximum allowed values will be displayed above the indicator.

The **RESET** buttons will reset the trip counter portion of the flow indicators. The **TOTAL FLOW** readings will not be reset.

The **FREEZE PROT.** indicator displays the state of the freeze protection mode.

5.1.7. Event Page

The Event Page keeps a running history of alarms as a troubleshooting aid.

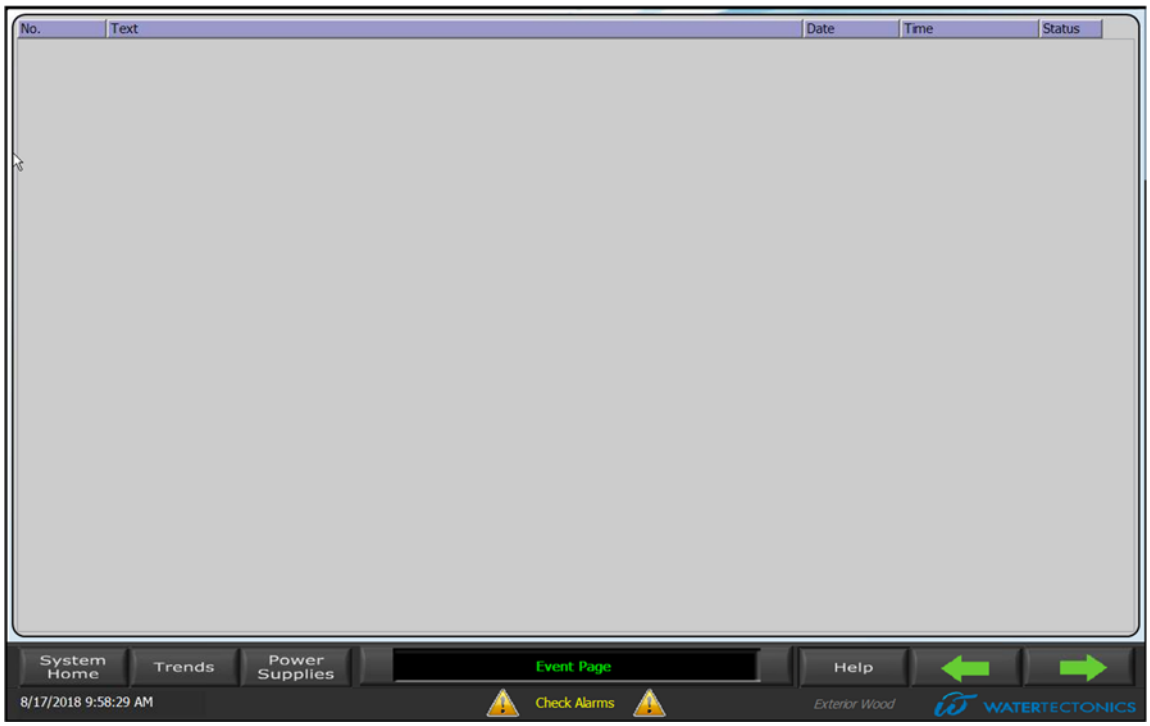


Figure 37: Event Page

5.1.8. Trends Page

The Trends Page displays key electrical parameters, such as EC treatment voltage and current, and hydraulic parameters, such as flow rates. Tracking these parameters over time can aid system tuning and troubleshooting.

Figure 38: Trends Page

5.1.9. Alarms Page

The Alarms Page displays alarm details and provides interface options to acknowledge and clear alarms. The Alarms Page gives the date, time, and a text description of the alarm condition. Press the Alarm Button or green arrows to jump to the Alarms Page.

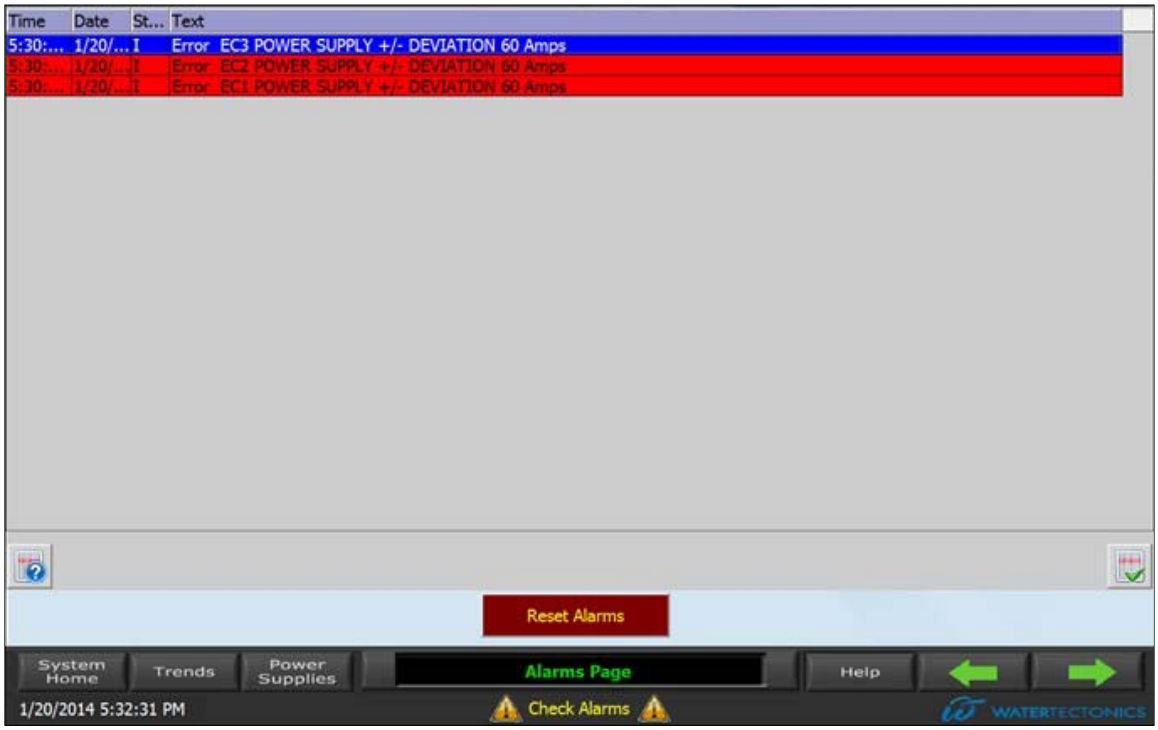


Figure 39: Example Alarms Page

The Status column indications include the following states:

- **I** – The alarm condition signaled to the PLC. The alarm condition can be continuously occurring or input once. The alarm is not cleared, acknowledged, or reset.
- **IO** – The alarm condition signaled to the PLC, and is now clear.
- **IA** – The alarm condition signaled to the PLC, did not clear, but the operator acknowledged the alarm.

ALARM ICON STATES:

Icon	Function
	Allows the operator to acknowledge an alarm. If the alarm condition is clear, the alarm will be removed from the list.
	Allows the operator to view more information about an alarm.
	Allows the operator to reset the system after alarms are cleared and acknowledged.

Table 9: Alarm Icons

5.2. Startup Procedure

Perform the following steps to start up the WaveIonics system:

5.2.1. Verify Phase Rotation

Check for proper phase rotation by briefly turning on the HVAC unit and ensuring the compressor comes on when set to cool the room. **The fan will blow air even if the phase is reversed, so it is imperative compressor is running.** A second person should stand outside next to the HVAC unit and listen for the compressor to start, or you can verify that the air coming out of the supply grill gets much cooler than the return air.

Note: The HVAC pulls some air from outside the Conex, which may be cooler than the air inside the Conex, which may be confused with the compressor running. Check the phase rotation after disconnecting and reconnecting the system power cables. Incorrect phase rotation will result in the air conditioner not working and may result in permanent damage.

Because the system has external pumps that will be hardwired during installation, the phase rotation of each pump must be verified. Using the **HOA** switch, briefly cycle each pump while a second person observes the pump rotation. The proper direction of rotation is marked on each pump. If the pump rotation is incorrect, swap any two leads at the pump. Always follow proper lockout/tagout procedures to ensure safety.

5.2.2. Treatment Train Startup

1. Make sure all **E-Stop** buttons are pulled out and reset.
2. Press the **E-STOP RESET** button on the control cabinet.
3. Verify the green **SYSTEM STANDBY/OK** light is illuminated.
4. Review the settings on the HMI and verify that water level, voltage, and current settings and setpoints are correct.
5. Verify all reservoir, discharge, settling tank, and other hydraulic path valves are open.
6. Verify all manual isolation valves to the EC cells are open.
7. Open all manual EC stage isolation valves.
8. Set the **EC VALVE** switch to the **AUTO** position.
9. Set the **EC SYSTEM 1–4** switches to the **AUTO** position.
10. Set the **MEDIA FILTER SYSTEM** switch to the **AUTO** position.
11. Set the **MEDIA FILTER CONTROLLER** switch to the **AUTO** position.
12. Set the **EC PUMP** switch to the **AUTO** position.
13. Set the **MEDIA FILTER PUMP** switch to the **AUTO** position.
14. Set the **BACKFLUSH PUMP** switch to the **AUTO** position.
15. Verify water flow. Prime the pumps or purge air from the system if necessary to achieve optimal pump performance.
16. Set the **CAUSTIC, BRINE, AIR BLOWER**, and **CO2** switches to the **AUTO** position.
17. Set the **PRE-TREATMENT PUMP** switch to **AUTO**.
18. Review the current and voltage display on the HMI. Verify that the preset amperage is being met and the voltage in each EC subsystem is not in error.

19. Inspect the sc1000 controller to ensure that water quality parameters are within acceptable ranges.
20. When necessary, such as after initial startup, after a period of inactivity, and during regular maintenance intervals, take a grab sample from before the discharge point.
21. Use hand-held pH and conductivity measurement tools to examine the grab sample water characteristics. Compare these results to the measurements displayed on the sc1000.
22. If additional treatment is necessary, set the **POLYMER** pump switch to the **AUTO** position.

5.3. System Standby

The system will transition from run to standby if the pre-treatment tank level is at or below the **OFF** setpoint. The system will remain in standby until the pre-treatment level rises above the ON setpoint.

At least one **EC SYSTEM** switch and the **MEDIA FILTER SYSTEM** switch **must** be in the **AUTO** position for the system to be in standby mode. Too much or too little water at critical points, such as in the clear well or pre-treatment tank, will cause the system to wait until water levels reach programmed limits. After water levels are within normal parameters and with all control switches set to **AUTO**, the system will resume operation automatically.

If all conditions are normal and the system does not resume operation automatically, set the **EC SYSTEM** switches to **OFF** and then back to **AUTO** to exit standby.

Note: If one part of the system causes a standby condition, other parts such as individual pumps or subsystems may also be in an error state. Verify no alarms are present if an unexpected standby condition occurs.

The system displays the following indications when in standby mode:

- The green **SYSTEM STANDBY/OK** indicator flashes.
- The supply pumps do not operate.
- There is no influent flow.
- The power supply is idle.
- The electrically-actuated EC flow control valves are closed.
- The red **SYSTEM ALERT/FAIL** indicator may be illuminated if the system had an error before entering standby (for example, the EC subsystem registered an error condition). If there are no errors, the indicator will not be illuminated.
- There may or may not be water in the clear well.
- There may or may not be effluent flow, meaning the media filter can continue to operate even if the rest of the system is in standby mode until the water level in the clear well drops below the programmed **OFF** setpoint.

Possible causes of the standby condition include:

- There is no electric current flowing through the EC cells.
- Too much or too little water at critical points in the system, such as in the pre-treatment tank or clear well.

5.3.1. Error Reset

To reset an error turn the **EC SYSTEM** switches to **OFF**, wait three seconds, then turn the switches to **ON**. An alternative method is to clear all errors and press the **Reset Alarms** button on the Alarms Page.

5.4. Automatic Shutdown

An automatic shutdown occurs when the system detects a failure or out of tolerance condition.

Both the media filter and EC stages will automatically shut down if a supply pump flow rate drops below 20 gpm for 30 seconds. This prevents the supply pumps from running dry and causing equipment damage.

The EC stage will automatically shut down if any of the following conditions are true:

- A fuse or circuit breaker trips.
- Power supply current exceeds target current by more than 10 amperes for 30 seconds.
- An individual cell exceeds a temperature limit for 30 seconds.
- The actual cell current is 10 or more amperes below the target for 30 seconds.
- The EC stage exceeds maximum voltage or current limits for 30 seconds.

The system displays the following indications when automatically shut down:

- The red **SYSTEM ALERT/FAIL** indicator illuminates.
- The supply pumps do not operate.
- There is no influent flow.
- The power supply is idle or possibly in an error state.
- The electrically-actuated flow control valves are closed.
- There is no current flowing through the EC cells.
- There may or may not be water in the clear well.

5.5. System Shutdown

A normal shutdown, such as for maintenance purposes, transitions the EC and media filter stages from standby or run mode to off. To shut down the system, turn the following switches to the **OFF** position:

- EC SYSTEM 1–4
- MEDIA FILTER SYSTEM
- MEDIA FILTER CONTROLLER

For normal shutdowns, leave the pump control **HOA** switches in the **AUTO** position.

6. Maintenance

6.1. General

Inspect all system components regularly to verify they are operating properly. Consistently maintain a data log to monitor component performance. Over time, the historical data will indicate when certain items need cleaning and/or replacement.

Basic maintenance includes the following actions:

- Examine the system components for any signs of damage or malfunction.
- Inspect and clean the media filter, sanitary media filter, and GAC pods. Replace media or carbon when necessary.
- Check the polymer level in the polymer tote.
- Verify consumable levels are sufficient for pH adjustment.
- Review all system logs available on the HMI.
- Verify that the preset amperage control is functioning properly by monitoring the amperage display meter on the HMI and verifying the target current is achieved.
- Record all pertinent data in the treatment log.

6.2. Inspecting, Cleaning, and Replacing Cells

To remove an EC cell for inspection, cleaning, or replacement, complete the following steps:

1. Periodically check the EC cells and surrounding area for indications of problems such as leaks or loose interconnect power cables.
2. Power off the EC cells by turning the EC SYSTEM 1 – 4 switches to the OFF position.
3. Close the EC cell isolation valves and open the cell housing drain valve near the floor.
4. Loosen and remove the flange bolts.

   DANGER: Do not disconnect or reconnect any cell leads while the EC system is operating. Do not operate the system without the cell leads connected and the cells filled with water.
5. Remove the power cables from the top of the cell. Turn the cable until it removes easily.
6. Remove the pressure relief valve at the top of the cell. Grasp the slide ring and pull downwards while gently pulling upwards on the vent.
7. Remove the EC cell. Residual water may spill from the cell plates. Use caution when removing the cell to avoid plumbing damage.
8. Inspect the cell plates for sediment build up and thickness. If the cell looks dirty but the plates are substantial, clean the cell using a cell wash tote and pressure washer. Replace the cell by completing the remaining steps. If the cell appears consumed, it must be replaced.
9. Place the old cell in a waterproof container to avoid spillage.
10. Save the rubber flange gasket and put the gasket back in place to receive the new or cleaned EC cell.

11. Install the new or cleaned EC cell by placing a new cell in the old cell location or returning a cleaned cell to the EC cell subsystem.
12. Reattach the cell power cables. Ensure the cables are secure by pushing down and turning until the connection is tight.
13. Install the flange bolts with the following precautions:
    - Tighten the bolts in the following order: 1 and 5, 4 and 8, 2 and 6, 3 and 7.
    - Use no more than **30 lb-ft** of torque on each bolt.
14. Reattach the pressure relief valve.
15. Close the cell housing drains.
16. Open the EC cell isolation valves.

6.3. Media Filter Maintenance

Refer to the customer's media filtration system operation and maintenance manual.

Note: Periodic backflushing of the media filters to remove filtered sediment and debris from the media bed is essential for system performance and maintaining treatment flows.

6.4. System Disconnect and Circuit Breaker System

The system disconnect is located on the unit exterior on the side of a fused disconnect. The fused disconnect switch must be in the **ON** position for any part of the system to function. Set the handle to the **OFF** position and complete any required lock out/tag out procedures before attempting any electrical work or repairs to the system. All electrical work or repairs must be done by qualified personnel or a Water Tectonics employee.

The circuit breaker panel board and load center are located next to the control cabinet. All breakers are clearly labeled. If a circuit breaker has tripped, complete a thorough inspection of the associated system. A tripped breaker is usually an indication of a more serious issue.

To reset a tripped breaker, move the breaker switch to the **OFF** position and then to the **ON** position.

6.5. Verifying Level Transducer Connections

The level transducers connect inside the low voltage junction box. Periodically check the level transducer connections by verifying that the level signals appear on the HMI. If the level signals do not appear or are inaccurate, verify that the connections are secure inside the junction box by visually inspecting the terminals and lightly pulling on each wire.

Figure 40: Level Transducer Connections

7. Troubleshooting

This section provides a guide to troubleshooting problems that may occur during normal operation. Computer diagnostic assistance is available from Water Tectonics for all electrical/electronic parts and for component analysis.

Troubleshooting basic pump operations and plumbing is beyond the scope of this document. A qualified technician familiar with the setup and installation of the equipment is assumed to have performed basic hydraulic system checks.

For automatic sampling, monitoring, and data recording equipment and filtration system troubleshooting, refer to the manufacturer's documentation.

Problem	Diagnosis	Action
Discharge or recycle is turbid or looks dirty. **Note:** Though there are many factors that can contribute to this condition, an operator can check for certain causes immediately.	Media filter did not complete backflush cycle.	Perform a manual backflush as described in the media filter manufacturer's documentation.
	If system is also not meeting current (amperage) targets, the cells are clogged, loaded with material, or consumed.	Inspect cells and check maintenance records. Refer to the *Inspecting, Cleaning, and Replacing Cells* section.
Voltage readings are high and preset amperage is not met.	Current (amperage) target set point is incorrect. A typical target amperage is approximately 100 A.	Verify the set points on the HMI. (Voltage is adjusted programmatically to meet the target setpoint.)
	Cells are clogged, loaded with material, or consumed.	Inspect cells and check maintenance records. Refer to the *Inspecting, Cleaning, and Replacing Cells* section.
	Conductivity is below designed system specifications.	Check the salt level in the brine tote. Add salt if necessary. Verify the brine pump is functioning properly.

Problem	Diagnosis	Action
There is no water running through the system when system is set to **AUTO**.	The ON setpoint for the water level in the reservoir is too low to activate the supply pumps.	Adjust pump **ON** setpoint to below water level. **Caution:** Do not attempt to draw water from below the water intake level or damage to the pumps may occur.
	Pre-treatment tank level transducer is not functioning.	Verify connection between level transducer and system. Refer to the *Verifying Level Transducer Connection* section.
	Pre-treatment tank level transducer setpoints are incorrect.	Adjust the reservoir **ON** and **OFF** setpoints. Refer to the *HMI Interface Screens* section.
	Influent pipe is leaking.	Inspect influent pipe and repair leaks.
Media filter is continuously in backflush cycle.	Pressure differential control setting is incorrect.	Verify that the pressure differential control setting is correct. Refer to the **Error! Reference source not found.** section and media filter manufacturer's documentation.
	Backflush setting control knobs are incorrect.	Verify the preset and timing settings. Refer to the **Error! Reference source not found.** section and media filter manufacturer's documentation.
Media filter pressure differential is high.	Possible filter blinding.	Perform multiple manual backflushes until the condition clears.
EC supply pump or MF supply pump will not start and the **SYSTEM ALERT/FAIL** indicator is illuminated.	A circuit breaker or motor start protector is tripped.	Check and reset the system breakers and motor start protector. Inspect the system for signs of more significant problems.
EC supply pump or MF supply pump will not start and the **SYSTEM ALERT/FAIL** indicator is illuminated.	A VFD is in a fault condition.	Inspect the VFD displays inside the control cabinet. Refer to the *Siemens Sinamics V20 Inverter Instruction Manual* for error codes and reset instructions.

Table 10: Troubleshooting

7.1. Related Documentation

Refer to the following documentation for more information regarding system components:

Chem-Pro Diaphragm Metering Pumps C3 Series User Manual

GLI 3700sc Digital Inductive Conductivity Sensor User Manual

Hach Differential pH and ORP Sensors Data Sheet

Hach Inductive Conductivity Sensor User Manual

Hach sc1000 Controller User Manual

Hach Solitax sc User Manual

pH sc Digital Differential pH/ORP Sensors User Manual

Siemens Simatic HMI Devices Comfort Panels Operating Instructions

Siemens Simatic S7-1200 Programmable Controller System Manual

Siemens Sitrans F Flowmeters

Summit CC & FM Installation, Operation, and Maintenance Manual

Siemens Sinamics V20 Inverter(VFD) Instruction Manual

Customer-owned Media Filtration System Operation and Maintenance Manual

8. Routine Inspection Activities

The following section describes a typical inspection and maintenance schedule.

Maintenance Item	Startup	Weekly	Quarterly
Influent pH Probe Inspect electronic data recording equipment regularly and reference it against manual grab sample data and calibrated.	I	C	
Effluent pH Probe Inspect electronic data recording equipment regularly and reference it against manual grab sample data and calibrated.	I	C	
Inspect EC cells for plate loading and wear. Refer to the *Inspecting, Cleaning, and Replacing Cells* section for more information.	I	I	I
Inspect media filter pods according to the manufacturer's specifications. Refer to the manufacturer's equipment manual.	I		I
Inspect and verify all pumps are in proper working order according to the manufacturer's specifications.	I	I	I
Inspect and maintain safety of steps, railing, and entrance to unit.	I	I	
Inspect fittings and pipes for leaks or excessive wear.	I		I
Inspect piping, plumbing, and fittings. Check for leaks, breaks, and potential hazards.	I	I	
Verify the media filter pressure is within preset specified range / psi.	I		
Inspect level transducers. Verify float switches are functional.	I		
Service the turbidity probe. Refer to the manufacturer's documentation.			C

KEY: I – Inspect
C – Calibrate

Table 11: Inspection and Maintenance Schedule

8.1. Log Book and Record Keeping

Keep and maintain a log book in the trailer at all times. Record all activities, note adjustments, and record any changes made. Record the names of all personnel on site along with their arrival times and any other pertinent information on a daily basis.

The Hach sc1000 controller is capable of logging all influent and effluent water quality data including turbidity, pH, and conductivity. This information can be downloaded onto a laptop or SD card. This information should be periodically transferred to a more permanent location for storage. For detailed instructions about logging and downloading data, refer to the Hach documentation.

9. Inspection Checklist

WATERTECTONICS

Maintenance Inspection Overview

Inspector_____

Date_____

Item	Action
System Review	Operator system logs and notes -HACH data - System data - Flow rates
Inspection	System function with settings and parameters to include: relays, valves, solenoids, drains, contactors - Pre-treatment loop – Media filter and GAC operation and settings - Electrical connections - Cell vents
Calibration	pH probes - Turbidity probe – Conductivity probe - Thermal flow sensors

Quarterly Maintenance Inspection Checklist

Item	Review/ Inspection	OK	Not OK	Record Data/info	Action	Issues/Concerns
Operator Logs/notes	Review all operational logs/notes					
Flow Inspection	Subsystem 1 flow/cell inspection					
Flow Inspection	Subsystem 2 flow/cell inspection					
Flow Inspection	Subsystem 3 flow/cell inspection					
Flow Inspection	Subsystem 4 flow/cell inspection					
Flow Inspection	Influent vents, valves and relays					
Flow Inspection	Influent flow rate					
Flow Inspection	Effluent flow rate					
Flow Inspection	Effluent valves and relays					
Flow Inspection	Solenoids and contactors					

Item	Review/ Inspection	OK	Not OK	Record Data/info	Action	Issues/Concerns
Hach Data Controller	Influent settings					
Hach Data Controller	Effluent settings					
Media filter	Media					
Media filter	Pressure					
Media filter	Flow rates					
Media filter	Compressor					
Media filter	Control panel settings					
GAC	Carbon	N/A				
GAC	Pressure	N/A				
GAC	Flow rates	N/A				
GAC	Control panel settings	N/A				
pH Adjustment/ Pre-treatment	Consumables levels					
pH Adjustment/ Pre-treatment	Chemical Pump(s)					
pH Adjustment/ Pre-treatment						
pH Adjustment/ Pre-treatment	Regulator(s) & solenoid(s)					
Calibration	Influent pH Probe					
Calibration	Effluent pH Probe					
Calibration	Effluent Turbidimeter					
Calibration	Conductivity Probe					
Calibration	Auxiliary Probe(s)					

Customer Signature: _____ **Date:** _____